provided for agricultural departments in the graded schools of the State.

Referring to American colleges and universities, Dr. Brown gives it as his opinion that among the leaders of American university education there is a growing and surprisingly unanimous conviction regarding the directions in which improvement should be made in higher education in the States. It is to be rendered more coherent, vital, and democratic. As President Butler has remarked:—"The American college is under fire, no doubt. Well-directed intelligent firing will do it good. It is far from perfect, but it knows its job, and is working at it with the skill born of long and successful experience." The democratic movement in higher education has been emphasised during the year by the effort to organise in Massachusetts an institution which shall bring courses of college instruction home to all communities in the State in which it may be desired—a project which has been referred by the Legislature to the new State Board of Education for an opinion as to its advisability; by the step taken by Cornell University in the direction of the State university form of organisation, and by the beginnings at the University of Wisconsin of a more comprehensive and widely diffused system of university extension.

Within the year the University of Wisconsin has been a centre of public interest in a variety of ways, not the least important of which is the Vilas bequest, which is expected to amount to 400,000*l.*, and to be administered so that it shall eventually reach a total of 4,000,000*l.* The fact that the available income of this fund is to be devoted largely to research renders it an epoch-making endowment.

In addition to its treatment of the problems of American education, the volume provides an admirable series of summaries of educational progress in European and other countries. Separate chapters are devoted to educational problems in Hawaii, the Philippines, Porto Rico, the Argentine Republic and Chile, Great Britain and Ireland, France and Central Europe. Educational reform in China and current educational topics in foreign countries each receive special treatment.

These educational reports from Washington have often been praised in these columns, and it will suffice to say that the latest report fully maintains the excellence of its predecessors.

OLE RÖMER AND THE THERMOMETER.[1]

THE first thermometers of which the indications were independent of atmospheric pressure appeared in the latter half of the seventeenth century, but Fahrenheit was the first one to succeed, in 1710, in solving the problem of furnishing these thermometers with such scales that their indications agreed; these thermometers were much admired, and represented great progress. It may therefore be of interest to show that Ole Römer solved this problem before Fahrenheit, and that it was from him that Fahrenheit obtained his method.

From some stray remarks which I happened to come across in scientific literature of the eighteenth century, I saw that Ole Römer probably occupied himself with the construction of thermometers, and that some connection existed between him and Fahrenheit. These statements had the effect of inducing me to look for traces of Römer's work in the libraries and archives here in Copenhagen. In the university library I found what I was looking for—a work by Römer called "Adversaria," a volume of written papers in folio bound in a brown cover.[2]

The book contains a whole section about the thermometer, besides some scattered statements about temperature measurements, which I shall return to later. The arrangement of Römer's thermometer seems to me to be of considerable interest. Römer appears to have been the first to construct thermometers with the two fixed points, the temperature of melting snow—"Nix sine gelu et calore"—and the boiling point of water, and with the cubic contents of the tube divided into equal parts. Both Römer and Horrebow's remarks seem to indicate that this took place about the year 1702. The first part of this section is mathematical, and deals chiefly with the problem of dividing the cubic contents of a conical glass tube into equal parts. Römer finds a general method of making such a division, and calculates approximate formulas by the aid of which he may carry out more easily his calculations; he employs these formulas in dividing the cubic contents of a conical tube 8 inches long, intended for his "original thermometer," into four equal parts, and he gives the length of these parts when he determines that the scale of the thermometer is to have sixty divisions, and these are to be arranged in such a way as to read "boiling 60, snow without cold or warmth $7\frac{1}{2}$." After these preliminary investigations Römer gives complete instructions in four paragraphs for "the construction of an original[1] thermometer."

"(1) By means of a drop of mercury investigate whether the cavity of the tube, be it cylindrical or conical, is regular before the ball is blown out. Irregular forms are to be rejected; the cylindrical form may be employed without further investigation. With regard to the conical forms, proceed as follows:—

"(2) From the middle of the tube towards the outer points take the lengths of the drop of mercury.

"(3) When by means of this experiment the divisions have been divided into two equal parts, each of these parts is in turn divided into two equal parts proportionally by increase or diminution, and the whole tube will thus be divided into four equal parts.

"(4) When the thermometer is completed, filled and closed, fix by means of snow or crushed ice the point of division $7\frac{1}{2}$, by means of boiling the point 60."

After these instructions there are remarks written in Horrebow's hand and with his signature which are supplementary, and show also that Römer's thermometer existed after his death (1710):—". . . In 1739, Römer's widow sent me five glasses for thermometers which Römer himself had filled and divided with two points in accordance with his own rules given above. The alcohol in them is rather pale, although Römer coloured it with saffron in the usual manner. . . . After this was written, I asked Römer's widow if she knew whether Römer, after I had left his observatories, had made any change in his thermometer. She said that she did not know, but she gave me Römer's *vade mecum*, in which I found a loose sheet, which is pasted in here after the next sheet. On that I read that Römer fixed upon 8 as the dividing-point for snow, and thus, so far as we know, the alcohol never sinks below 0 in Copenhagen, and it is to be remarked that January 7, 1709, the alcohol only sank to $7\frac{6}{10}$."

The loose sheet which Horrebow mentions contains a table of temperatures which gives the temperature for every day from December 26, 1708, to April 1, 1709.

The two following pages contain a sort of table of corrections for the four divisions.

After this short account of the contents of the eleven folio pages which Römer devoted to the construction of his "new" thermometer, it will be appropriate here to give a short explanation of his method and to point out what is new in it.

The chief feature of the method is this: to base the division of the thermometer on two fixed points, the melting point of thawing snow and the temperature of boiling water, and to find the length of the degree by dividing the cubic contents of the thermometer tube between these two points into equal parts, taking into consideration whether the tube is cylindrical or not. The size of the degree is obtained on the basis of the fact that there must be between the freezing point and the boiling point 52·5 degrees of equal cubic content. If the tube is cylindrical the whole length between the two fixed points is divided into $52\frac{1}{2}$ equal parts, and 7·5 similar parts are added

[1] v. Kirstine Meyer: Temperaturbegrebets Udvikling gennem Tiderne og dets Forhold til vekslende Anskuelser om Varmens Natur. Gjellerups Boghandel. Inaugural Dissertation. (Copenhagen, 1909.)

[2] The language in "Adversaria" is chiefly Latin; the book will be published in 1910 under the auspices of the Kgl. danske Videnskabernes Selskab.

[1] Some weights which are still in existence from Römer's time, and probably are those that he constructed as standards for the new system of weights and measures introduced by the Act of May 1, 1683, bear the inscription "original weight." From this it may be inferred that "original thermometer" means "standard thermometer," and that it was Römer's purpose to introduce a standard for thermometers as for other units of measure.

below the freezing point, zero being thus determined. If the tube is not cylindrical, but conical, an investigation of the dimensions of the tube is made according to the method described in the introduction, the result obtained being the relation between the length of that part of the tube enclosing the seven-eighths of the cubic contents nearest the boiling point and the whole length which is to be employed for the 60°; in the example which Römer takes the conditions are such that the length of the tube between the boiling point and the freezing point must be divided into 52·2 equal parts, 7·8 parts to be added below the freezing point, zero thus being obtained. In using such a thermometer with a conical tube, it is necessary to have a table giving the readings in terms of degrees; thus the reading 7·8 on the length of the tube meant, in terms of Römer's thermometer, 7·5°, 15·563 meant 15°, &c.

Three questions naturally arise when we see that Römer used so much of his limited time in constructing on "original" thermometer:—(1) Is this interest in any way connected with the rest of his scientific or practical work? (2) Did he use the thermometers thus constructed for systematic measurements? (3) Have his new ideas in this line contributed anything to the improved construction of thermometers on the whole? In "Adversaria" there are indubitable indications that the first two questions are to be answered in the affirmative; he gives very excellent results of experiments on "the change of length in metals caused by cold and heat," and, furthermore, there is a sketch of an apparatus for comparative measurements of the expansion of gases and liquids when exposed to heat, and some good results of these measurements. There is also, as already mentioned, a series of measurements made with the new thermometer of the temperature of the air in Copenhagen during the winter of 1709. These measurements are of special interest, and are mentioned several times in the literature of foreign countries. The winter of 1709 was very severe. In an article in Phil. Trans., No. 324, 1709, W. Derham writes, in "The History of the Great Frost in the last Winter," about the conditions in Denmark:—"Dr. Woodward tells me, that in a lettre, he received from the learned Mr. Otto Sperling from Copenhagen, dated April 6, 1709, he calleth it Hyems Atrocissima. And I find it noted in the Minutes of the Royal Society of May 4, 1709. That Dr. Judichar said the ice was frozen in the harbour of Copenhagen 27 inches, and that April 9 N.S. people had gone over between Schone and Denmark on the ice. Which accounts give me a better opinion of some papers I have by me which were shew'd to the Society, concerning the frost at Copenhagen pretended to be taken from the observations of Mr. Römer. I should not entertain any the least distrust of the accuracy either of the instruments or observations of that eminent person were I sure they were his. But there are some passages and hints in those papers that lessened others as well as my opinion about them. 'Tis said there 'That such a frost hath not been known in the memory of man of these countries and *that*[1] *the frost on January 7 and February 23, 170$\frac{8}{9}$, did very nearly approach the Point of Artificial Freezing.*'" If we now look at the table of Römer's temperature observations from 1708–9 which is found in "Adversaria," it will be seen that it begins December 26, 1708, and continues until April 9, 1709, only that after April 1 there are not observations for every day, and this is no doubt due to the fact that the table is only calculated to show temperatures under 8°. The remarks along the margin are written in Horrebow's hand. The first remark is:—"So Römer had changed his first plan." The meaning of this is, as may be seen from Horrebow's other remarks in "Adversaria," that he thinks that Römer had placed 8 at the melting point instead of 7½ as earlier.

Now the table shows that on February 23, exactly the date which Derham especially mentions, the thermometer went down to about Römer's zero. It is important to note the exact wording of Derham's remark, "that the frost, February 23, 170$\frac{8}{9}$, came near the temperature for artificial freezing." So it is evidently taken for granted here that *Römer's zero was the temperature of a freezing mixture*, a fact which Derham must have obtained from the report sent from Denmark, since he was not acquainted with Römer's scale. This remark is of special importance for the question as to whether, and if so through what channels, Römer's thermometer has had any widespread influence. The answer is in the affirmative, and the way in which Römer exercised a wide influence was through his influence on Fahrenheit. I shall now proceed to prove that such an influence was exercised by Römer.

[1] Emphasised by K. M.

In the first place, there are some direct statements about this matter. The most important is by Boerhaave, who, in writing about Fahrenheit's thermometer, says:—"Now it is said that the eminent mathematician Römer in the year 9 of this century observed in Danzig a winter-cold down to the first degree of *this same* thermoscope, of which he himself was the first inventor. Then he increased it with 32° below the freezing-point."

So here it is stated quite distinctly that Römer was the first inventor of Fahrenheit's thermometer; and importance is to be attached to Boerhaave's words about this matter, because he was closely connected with Fahrenheit, who had constructed his thermometers, and whose skill as an instrument-maker and experimenter he often speaks of in terms of praise. That Römer should have made measurements in Danzig in 1709 must be a mistake, which can easily be accounted for by the fact that there are accounts of measurements made in Danzig the same winter with a similar thermometer. At least, I have not been able to find any indications that Römer was in a foreign country at the time mentioned, and his many official duties, his delicate health, and that very list of temperatures for Copenhagen which was sent to the Royal Society make it improbable that he was away from home.

On the other hand, it is related in a biography[1] of Fahrenheit, written four years after his death, that after 1706 he made many difficult journeys by sea and by land, and conferred with the most famous mathematicians in Denmark and Sweden; it is probable that Ole Römer was one of the famous men whom he visited, and then Fahrenheit must have visited him just at the time when the "original thermometer" was used; if Boerhaave's statement is correct, it must be possible to trace Römer's influence on Fahrenheit's thermometers. What Fahrenheit could learn from Römer was chiefly the principle of the two fixed points as a basis for the thermometer scale. According to Fahrenheit's own brief account[2] of his method in the construction of his thermometers, he does, in fact, use fixed points as a basis for his scale, but he mentions three: the temperature of the freezing point, the temperature of a cold mixture, and the temperature of the healthy human body; the last, however, is apparently only used as a sort of check, because Fahrenheit does not wholly rely on the constancy of the temperature of the cold mixture. Now Fahrenheit probably took the two fixed points from Römer, since the zero of Römer's scale, as was evident from Derham's account, was identified with the temperature of a cold mixture, and it appears that the scales of several of the oldest of Fahrenheit's thermometers have the same numeration as Römer's. These thermometers are mentioned in various places; Grischow[3] especially has a full comparison of the somewhat varying scales which Fahrenheit used at different times.

According to Grischow[4] and others,[5] Fahrenheit is said to have confided to his tutor in mathematics, Barnsdorf (from Rostock), the secret of the method of division used on his thermometer, which he maintained was such that anyone who knew it could construct thermometers which agreed. Grischow writes that this happened "circiter 1712 and 1713 nise jam ante." Shortly after that Fahrenheit travelled to Halle and Leipzig, and then Barnsdorf, in conjunction with a colleague named Lange, tried to construct thermometers after the instructions. The scale on these was somewhat different from that on the thermometers which were generally known later as Fahrenheit's, and we read about Barnsdorf that he probably retained "the older or oldest Fahrenheit division." Now from the table it appears that Barnsdorf's thermometers have 7½ at

[1] Altpreuss. Monatsschrift, ii., 1874, contains a fragment edited by E. Strehlek.
[2] Phil. Trans. London, vol. xxxiii., 1724, pp. 78–84.
[3] Miscell. Berolienses, t. vi. (printed 1737).
[4] *Loc. cit.*, p. 271.
[5] Cotte, "Traité de Météorologie," 1774, p. 129.

the freezing point and $22\frac{1}{2}$ at the temperature of the human body, and these larger degrees are again divided into smaller ones, namely, each degree into eight. At all events, this idea of placing $7\frac{1}{2}$ at the freezing point, together with all the other facts that have been mentioned, seems pretty certainly to prove Römer's influence, since it is highly improbable that two persons independently would both think of placing $7\frac{1}{2}$ at the freezing point. Barnsdorf's zero is somewhat higher than that of the later Fahrenheit thermometers.

There is other evidence that Fahrenheit used $7\frac{1}{2}$ at the freezing point and had his original zero a little higher than the later one. In 1737 Prof. Dn. Kirch described[1] a thermometer which he had received from Fahrenheit more than twenty years before. He states there that his thermometer has $7\frac{1}{2}$ at the freezing point, and that his zero lies somewhat higher than that on the later Fahrenheit thermometers.

One more thermometer—perhaps the very oldest—seems based upon a division with fixed points and a scale like Barnsdorf's, although the division, apparently, is quite different. Grischow writes in 1740 that a large thermometer which Fahrenheit had constructed thirty years before for the Royal Society in Berlin, and consequently constructed with the greatest care, still agrees completely with the little thermometers which Fahrenheit had sent a short time before from Amsterdam to Berlin. These small thermometers were graded with the help of two or three fixed points, and are throughout like those we use now. So the first thermometer was also constructed according to fixed principles, for such agreement cannot be due to mere chance; a similar thermometer, which had been used for observations in 1709, and which certainly is one of the first Fahrenheit thermometers constructed, was found in Danzig in 1740.

This thermometer was apparently divided after the manner of the Florentine thermometer: 90 at the temperature of the body, 0 at about summer heat, 90 at the lowest degree of heat (which accordingly corresponded to zero on a Fahrenheit thermometer), and 30 at the freezing point. From the lowest to the highest degree of heat, then, there are $180° = 8 \cdot 22\frac{1}{2}$, from the lowest degree of heat to the freezing point $60° = 8 \cdot 7\frac{1}{2}$, accordingly like Barnsdorf's.

In 1714 Fahrenheit constructed two thermometers for Chr. von Wolf, Chancellor of the University of Halle, who was very enthusiastic about them, and has given a description of them.[2] The scale had 26 degrees; the second degree on the scale was marked "greatest cold," so that from this point to the top of the scale there were 24 degrees; the eighth degree was marked "cold." It reminds us perfectly of a scale which Grischow gives for the older Fahrenheit thermometers with the fixed points 0, 8, 24, which later were changed to 0, 32, 96. So here Fahrenheit hesitated—just as, perhaps, Römer did, according to Horrebow's opinion—and he took 8 instead of $7\frac{1}{2}$. However, taken all in all, there are strong indications that it is Ole Römer's strange number for the freezing point which is the origin of the 32° Fahrenheit now used for this point.

Now, perhaps the objection may be made that if Römer's scale were to be traced in Fahrenheit's, we should find $4 \cdot 60 = 240$ at the boiling point, and not 212; but there is an explanation for this. According to those descriptions of the oldest thermometers which are given above, it appears that the zero in the later thermometers is placed lower than in the earlier ones. Now if the zero in the earlier ones coincided with that of Römer's, the degrees on them must have been shorter than on the later ones, since there must be the same number of degrees within a shorter limit. In the later thermometers the number for the boiling point was found by dividing the space between zero (chiefly determined by means of a cold mixture) and the freezing point into thirty-two equal parts, and marking equal parts off above the freezing point; since these degrees are longer than the older ones, there must be fewer within the same limit, therefore 212, and not 240, at the fixed point, the boiling point.

KIRSTINE MEYER.

[1] Misc. Berol., t. v., 1737, p. 129.

[2] Acta Eruditorum, 1714, p. 381.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

LONDON.—The Board of Studies in Ethnology will be designated in future the "Board of Studies in Anthropology."

Mrs. Norman-Robinson has offered to found a scholarship in craniology and anthropometry, tenable at University College, in memory of the late Dr. R. C. Benington.

The principal of the University (Dr. H. A. Miers) has been elected chairman of the University Press Committee of the Senate.

In addition to the post-graduate course of lectures at University College, London, by Prof. J. A. Fleming, on "The Theory of the Propagation of Electric Currents in Telegraph and Telephone Cables and in Electric Conductors," two other post-graduate courses have been arranged, namely:—(1) "The Ideal Arch, Metal and Masonry, Theory and Design," by Prof. Karl Pearson; (2) "Steam Turbines," by Messrs. W. J. Goudie and E. G. Izod, both beginning on January 21.

Among the advanced courses of scientific lectures for the coming term arranged in connection with the University we notice the following. The lectures are intended for advanced students of the University and others interested in science, and admission to them will be free. A course of ten lectures on the "Evolutionary Aspects of Palæobotany" will be given by Mr. E. A. Newell Arber at University College, at 4.30 p.m., on dates which are published in the *London University Gazette*. Three lectures on "The Geology and Physiography of Arctic Europe" will be given by Prof. E. J. Garwood at University College on Thursdays, at 5 p.m., beginning on February 24. Dr. W. N. Shaw, F.R.S., will give a course of lectures on "Dynamical Meteorology, with Special Reference to the Forecasting of Weather," at the London School of Economics on Fridays, at 5 p.m., beginning on January 21. A course of eight lectures on "The Rate and Conditions of Chemical Change" will be given in the physiological laboratory of the University by Dr. V. H. Veley, F.R.S., on Fridays, at 5 p.m., beginning on January 21. A course of fourteen lectures on "Protozoan Parasites, with Special Reference to those of Man," will be given at the Lister Institute of Preventive Medicine, Chelsea, by Prof. E. A. Minchin, on Mondays and Thursdays, beginning on January 17, at 5 p.m. A course of three lectures on "The Marsipobranchii," by Mr. F. J. Cole, will be given at University College on Mondays, beginning on January 24, at 5 p.m. A course of three lectures on "Amphioxus," by Prof. E. W. MacBride, F.R.S., will be given at the Imperial College of Science and Technology on Mondays, beginning on February 14, at 5 p.m.

ACCORDING to the Chicago newspapers, plans are in contemplation for giving the University of Chicago the finest physical laboratory in the United States, if not in the world. It is said that before the building is complete it will have cost 200,000*l*. All the money is to be furnished by Mr. Martin Ryerson, president of the board of trustees of the University, who was also the donor of the present Ryerson Laboratory at Chicago University.

A COMMITTEE, with Mr. C. P. Trevelyan, M.P., Parliamentary Secretary to the Board of Education, as chairman, and Mr. W. R. Barker, of the Board of Education, as secretary, has been appointed by the President of the Board of Education to inquire into the administration of elementary education endowments. The terms of reference are "to inquire into the administration of (*a*) endowments, the income of which is applicable or is applied to or in connection with elementary education, and (*b*) small educational endowments other than the above in rural areas, the application of which to their proper purposes presents special difficulties; and to consider how far under the existing law it is possible to utilise them to the best advantage; and whether any, and, if so, what, changes in the law are desirable in the direction of conferring upon county and other local authorities some powers in respect of such educational endowments or otherwise."

IN an article on "Some Problems of Secondary Education," in the current issue of *The School World*, Mr.